FEATURE

Interview With Jean-Claude Bradley
The Impact of Open Notebook Science

by Richard Poynder

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Jean-Claude Bradley is an organic chemist at **Drexel University** in Philadelphia. As with most scientists, Bradley used to be very secretive. He kept his research under wraps until publication and frequently applied for patents on his work in nanotechnology and gene therapy.

However, he asked himself a difficult question 5 years ago: Was his research having the kind of impact he would like? He had to conclude that the answer was "no," and this was partly a consequence of the culture of secrecy that permeates research today. So Bradley was determined to be more open. Since his collaborators were not of the same mind, he severed his ties with them and, in 2005, he launched a web-based initiative called **UsefulChem**. As the name implies, the aim of the initiative was also to work in the world of useful science and, today, Bradley makes new **anti-malarial** compounds. This is potentially very useful: Malaria **kills** millions of people each year and, since most of those people live in the developing world, large pharmaceutical companies are disinclined to devote much time to developing new treatments.

And in the interests of openness, Bradley makes the details of every experiment done in his lab freely available on the web. He doesn't limit this to just a description, but he includes all the data generated from these experiments too, even the failed experiments.

He named his new technique Open Notebook Science (**ONS**), which he explains "is a way of doing science in which—as best as you can—you make all your research freely available to the public, and in real time." Unlike open access (**OA**), ONS aims to make raw scientific data (rather than published research) freely available within hours of production, not after the months or years involved in peer review.

Bradley quickly realized that he could create compounds much more efficiently if he could predict the solubility of the products he used when placed in different solvents. But there was no central source of solubility measurements either on the web or in fee-based databases. So he began doing the measurements himself and then depositing them in a **database**.

And in the spirit of the **open source software** movement, he reached out to the wider scientific community in 2008, launching a **crowd-sourcing** project called the **Open Notebook Science Challenge**. "We have drawn up a list of different compounds and solvents that are priorities and students are asked to measure their solubility," he says.

Bradley has accumulated nearly 700 solubility measurements this way. Combined with those culled from the literature, there are now more than 1,500 measurements in his database. Meanwhile, his **Reaction Attempts** database contains the details of 623 reactions. Both databases are freely available on the internet using querying tools developed by collaborator Andrew Lang from Oral Roberts University.

Of course, Bradley is not the only person using the internet to develop more effective research techniques. His work is part of a larger development generally referred to as **open science**, which includes the OA and **open data** movements plus much of what is called **eScience**.
Nevertheless, if ONS is widely adopted, scientists could see a radical change in the way laboratory science is done, which would have quite an impact on their work.

The following interview, which has been edited for length and style, provides a closer look at Bradley's work and the impact of ONS. An abridged version of the interview is available in the September print edition of *Information Today*.

Q: Can you tell us about your job and research interests?

A: I am an associate professor of chemistry and an **organic chemist** at **Drexel University** in Philadelphia. I have worked in a number of different areas, including gene therapy and nanotechnology, but my main activity today is making new **antimalarial** compounds. That's the official focus of the lab.

Additionally, in the process of doing this we discovered that sometimes these compounds will precipitate out in pure form. So we are also trying to better understand their solubility properties.

And for the past 5 years, I have been practicing **open science**.

Q: For nonchemists, can you clarify what you mean when you say these compounds sometimes precipitate out in pure form?

A: To create a **chemical reaction**, we mix four different **reactants** in a solvent. The consequent reaction will occur in many **solvents** but the **precipitation** will only happen if the product has a low solubility in the solvent.

As I say, sometimes the product will precipitate out spontaneously. Since it is much easier to isolate the product if it precipitates from the solution, as opposed to remaining soluble, that is a better outcome. So if we could predict the solubility of the products we used, maybe we could pick a better solvent to make that happen more often.

However, it turns out that there is actually very little solubility information available today, either on the open web, or in toll-access journals. That is why we are creating the information ourselves and using open methods to do so.

Q: In September 2006, you coined the term Open Notebook Science (ONS). What is ONS?

A: It is a way of doing science in which—as best as you can—you make all your research freely available to the public and in real time. For a chemist, this typically involves making your lab notebook publicly available on the internet.

The underlying philosophy is that there should be no insider information. In other words, the group making the data available should not know any more than someone would be able to deduce by reading their open notebook.

Q: Is there any data that you don't make public?

A: The Wikipedia **entry** on ONS says that the default position assumes you make all your data available immediately, that is, within hours at the very latest.

However, there is also what we call pseudo or partial notebook science (PONS), a term that has evolved to reflect the fact that some scientists may not want to share all their experiments, or they may only want to share them after a delay.

Q: But you adhere to the principle that all data should be freely available immediately?

A: Exactly. And one important reason for doing that is that it means people can see your failed experiments.

Q: Is it true that you used to be a secretive scientist and regularly applied for patents?

A: That's true. I was very secretive and I have several patents from when I was working in nanotechnology.

Useful Chemistry

Q: Why did you decide to adopt an open approach?

A: In thinking about what has meaning for me as a scientist, I realized that the work I was doing wasn't having the kind of impact that I would like it to have, and it was not benefitting mankind in the way I would have hoped. I concluded that this was partly a consequence of secrecy. However, I couldn't be open with the project I was then working on, because I was collaborating with someone who didn't feel the same way as me.

My decision to do open science meant cutting ties with my previous collaborators. Having done that in 2005, I started the project **UsefulChem**.

Q: UsefulChem is the name of your blog?

A: Correct, and in my first post, I said that I was going to find something useful that I could do as a chemist. So I began **looking** for phrases in chemistry articles that said there was a pressing need for something. That is how I came up with the idea of working on malaria. …

Since this disease primarily affects people in the developing world, big drug companies are unlikely to throw a lot of money at it. They prefer working on diseases that have a potential to earn them a good income. It was for that reason that we ended up working on malaria rather than HIV for instance.

Q: While transparency helps other researchers from repeating unsuccessful experiments, what other benefits does ONS provide?

A: The No. 1 benefit is that it enables you to connect with like-minded collaborators. If I had not started practicing ONS, I would never have interacted with some of the people I have; in fact, I would not even be in the antimalarial area.

Q: Why not?

A: Because our very first collaboration was with a nonprofit called **Find-a-Drug**. By using some **SETI-type software**, which runs on lots and lots of users' computers when they are idle, Find-a-Drug had identified a certain group of compounds that were likely to be active against malaria.

When I contacted Find-a-Drug, it shared its dataset with me. So I was able to start out with a virtual library of compounds that might be active against enoylreductase. [**A target** for the development of antimalarial agents].

Q: So you were off to a flying start because someone was willing to share their data with you in an open and nonproprietary way?

A: Right. The other important point to make is that when you say to people, "Does anybody want to collaborate with us in an open way," it is completely different to saying, "Everything we do is going to be patented, so please sign this non-disclosure agreement before we even talk about collaboration." These are very different approaches, and very different people respond to them.

Another advantage of using an open notebook is that people are able to assume that you haven't done something if they can't find it in your notebook. That is a powerful way to catalyze collaboration, because if people are confident that you have not taken a certain step, they are more likely to be motivated to contribute.

ONS Challenge

Q: Is ONS as much of an ideology as it is a scientific method?

A: It's a philosophy. The assumption is that you share things unless there is a really compelling reason not to. For instance, you wouldn't share personal information about your students without their consent. But sharing is the norm, and you share anything you consider relevant to the scientific discussion.

Q: So ONS could actually increase the pace at which science develops by not duplicating experiments and by pooling information?

A: Exactly. As I said, when we started out, we had tremendous problems trying to find solubility information. However, as a result of our work, a lot of solubility information is now freely available that was not available before.

We have about 100 people each day search our site for specific solubility measurements, which most comes from Google or Wikipedia. I know these people are getting their questions answered because I can tell from their queries.100 is not an insignificant number. And none of this would be possible if we had kept our data closed. It is also very satisfying for my students to do an experiment today and know that tomorrow someone may take a look at it and use it.

But the thing I am most proud of is the **Open Notebook Challenge**, which is something we started a year and a half ago.

Q: What is the ONS challenge?

A: It is a challenge for students to measure solubility data**. The idea is to **crowdsource** the solubility measurements of chemicals in common solvents such as methanol, ethanol, benzene, chloroform, acetone, etc.

Q: How does the challenge work?

A: We have drawn up a list of different compounds and solvents that are priorities and students are asked to measure their solubility. Those who contribute data can earn an award; and all they need to do to take part is use an open lab notebook. The judges then come in and comment on their notebook.

Students are not judged solely on the number of measurements they make but on how good their science is and how responsive they are to the judges' comments and critiques. We believe it is preferable that they do a few decent measurements than that they produce 100 measurements that we will then have to discard because they weren't recorded properly.

(We don't delete measurements but mark them as "DONOTUSE" in the database. These flagged results are not included in typical searches but they are still there for subsequent investigation by anyone.)

Q: Do you award cash prizes to the students taking part?

A: Yes, those taking part can get a $500 cash prize. To date, we have given out 10 prizes, and another five awards are currently being decided, thanks to funding from the **Royal Society of Chemistry**. We also recently published **a book** with all the solubility measurements. This includes the names of the students as co-authors**, along with their bios and pictures, so we have produced a very concrete product as well. But above all, ONS Challenge demonstrates the value of open science.

New Tools

Q: Since ONS is clearly a product of the internet age, why did it only emerge in 2005?

A: The availability of extremely high-quality, freely hosted tools is a big factor. The two main ones we use are **Wikispaces** and **Google Spreadsheets**. These were available in 2005, but not in 2000, as far as I know. If people had to pay for tools such as these, it would be a huge barrier to getting involved.

Q: Since you use a wiki and Google Spreadsheets, have a blog, and are creating a molecule database, how does it all fit together?

A: We have a free Wikispaces account that acts similarly to a paper notebook in the sense that a page of the wiki is like a page in a lab notebook. Then we put a lot of raw data into Google Spreadsheets and link to that from the wiki.

The principle is that if anyone wants to find out what happened in any experiment we have done, they can simply go to the wiki and review all the details. And if the experiment included a calculation, they are automatically directed to the Google Spreadsheet containing the data.

In addition, if we take any pictures, or **NMR**s (which are essentially machine-generated graphs characterizing a compound), we link to those from the wiki too. Since we have a lot of NMRs, we also provide a way of **viewing them graphically**.

Q: How?

A: Most NMR results are in **JCAMP-DX** format, which can be viewed interactively via a browser using the JAVA application **JSpecView**.

Q: The tools you mention are essentially Web 2.0applications. Other advocates of open science in chemistry (e.g., Peter Murray-Rust) seem more focused on Web 3.0 and the semantic web. Presumably you are interested in these too?

A: Absolutely. The semantic web is one of the main long-term goals of ONS. But we always assumed that the first step was to record the information in a human-readable format, and that is where we started.

Q: How would an open lab notebook fit into a Web 3.0 environment?

A: Once you have your data in a human-readable format, you can abstract it and put it in a format that machines can understand because a machine wouldn't do very well if it landed on a web page containing only human-readable data.

So we put our solubility data in a master Google spreadsheet containing the **SMILES** of all the compounds.[The Simplified Molecular Input Line Entry specification unambiguously describes the structure of chemical molecules by means of short **ASCII strings**]. We then link to the spreadsheet from the lab notebook.

Once this information is in a database format that a machine can understand, and we can automatically convert the Google Spreadsheet into an **XML** feed, for example.

We have also undertaken a similar process for the Microsoft **OData**project using our reaction data. And links to the **Solubilities Sum spreadsheet** and **OData XML** feed are **available** on Wikispaces.

Q: The Open Data Protocol [OData] is a Microsoft-led initiative designed to facilitate datasharing on the web? How does it work?

A: And when we saw the call for the OData project, we submitted our solubility information. We use **ChemSpider** to track the molecules [ChemSpideridentifies and extracts chemical names from documents and webpages and automatically converts the chemical names to chemical structures]. And we chose ChemSpider because it allows you to call **web services**, so we can call up the molecule images and display them automatically.

Open vs. proprietary

Q: There are a number of other proponents of ONS today. Cameron Neylon, for instance, has an open notebook in the biological sciences.

A: That's right. Neylong is **working** on **sortase** inhibitors, and producing antibacterial compounds. He uses different software to us, but the idea is exactly the same: to make things openly available and provide links to the experimental data for anyone who wants to take a look.

Q: How successful has ONS been to date?

A: It depends on how you define success. The percentage of scientists who are open today is still very small. However, a number have adopted ONS, including Neylon. Another is **Steve Koch**, who is an associate professor at the **University of New Mexico** . Like Neylon, he works in the biological area, looking at **actin filaments**. Koch decided he wanted to be open after meeting Neylon, and his lab has chosen to use the **OpenWetWare** platform. OpenWetWare is a generic place for keeping information about your lab, but it can also be used to keep an open lab notebook.

Q: Isn't Mat Todd at the University of Sydney another recent convert?

A: Correct. Mat is working on praziquantel (**PZQ**), which is used in the treatment of **schistosomiasis**, another illness primarily affecting people in the developing world. Todd uses the **Synaptic Leap** website, as well as Neylon's system and has recently been warping up his openness.

In fact, I am very pleased that Todd has his students and post-docs record their experimental details in open notebooks. He and I are both working on similar projects so it is the first occasion where two open notebooks

genuinely intersect.

Q: Can you give me an example of how this intersection works?

A: Well, I follow Todd's work, and I noticed that his students were starting to put data up on their lab notebook. When they had released enough data that it was possible to figure out what was going on, my collaborator **Andy Lang** and I realized that the **Ugi reaction** hat we use to do our experiments could also be used to make the compounds that Todd needs. And because Todd had put up all the details of the experiments he had done, I could be sure that he hadn't done it himself. So we tried doing it.

However, unfortunately, after we had done the experiment, Todd **found that a German patent** had recently been awarded for the process, so he won't be able to use it after all.

I posted about this on my blog, pointing out that we had missed a good opportunity.

Q: How so?

A: Had we done that work 3 or 4 years ago (which we might easily have done) and recorded it in our open notebook, we might have been able to block the German patent.

Q: That incident reminds us that there are limitations to openness?

A: Sure. But it also reminds us that one of the best reasons for using ONS is to prevent people blocking science with patents.

Q: By describing a process or method in an open notebook, is it possible to create prior art, and could this prevent others from patenting it?

A: And when patents have the effect of preventing the humanitarian use of compounds (as in many cases they do), it is a good thing to block them.

Q: With such a constant tension between open and proprietary approaches, does ONS mean never taking a proprietary approach? Could you envisage ever applying for another patent?

A: ONS doesn't preclude patents. Steve Koch, for instance, produces things that are patentable, and he tells me that he is currently trying to get his university to apply for a patent on his behalf.

Of course, the problem is that once you have posted information in a lab notebook, you have disqualified yourself from applying for a patent in most parts of the world. And in the U.S., you would need to apply within a year of posting the information.

Most research offices and Principal Investigators (**PIs**) might feel that the protection provided by a U.S. patent alone is not enough to justify investing the time and resources needed to apply for a patent. Having said that, Koch's** university research office recently agreed to file exclusively for a U.S. patent.

Q: Do you know if any labs, research institutions, or funding agencies currently encourage or require ONS as a matter of policy?

A: Well, the U.S. National Science Foundation (**NFS**) recently published a new data management policy that requires PIs to explain to reviewers how they are going to manage the data they produce. But there is no requirement that the data be open; it just says that PIs have to consider how they are going to store and share the data. But that's a start.

By the way, Todd recently received **funding** for his open project. While I doubt ONS was a requirement for the funding, he would certainly have said what he was going to do, and I think that would have been seen as a plus.

But you know, I don't actually think it would be a good idea to make ONS mandatory. In the U.S., we have the **Bayh-Dole Act**, for instance, which says quite clearly that university researchers can apply for patents. If you required them to share all their information in real time, they wouldn't be able to do that anymore.

In addition to the intersection between our work and Todd's, there is potential for another interesting intersection. Andy Lang, who writes code for me and **is a mathematician** at **Oral Roberts University** in Oklahoma, recently sent one of his students, **David Bulger**, to spend a few weeks at my lab in Philadelphia. Bugler then went to Southampton and spent a couple of weeks with Neylon. So he learned how to make Ugi products in my lab, and then how to do assays of sortase with Neylon. And although he has since returned to Oklahoma, he continues to use Neylon's lab notebook. So we are starting to see intersections not just of people working on the same products but intersections across products.

In fact, we have considered working on sortase inhibitors. Right now, I just don't have enough students, but there is a potential overlap there that we might exploit in the future.

Q: Once the number of open notebooks reaches a certain level, is it possible that we might see some intersections starting to grow exponentially, which, at some point, may trigger a step-change in the way

science is done?

A: The networking is the absolute best reason to do these things. And even if you only look at it from a selfish, rather than idealistic point of view, being open allows you to get more done. You might be more likely**, for instance, to publish a greater number of papers since the opportunities for finding collaborators increase.

Risks and Limitations

Q: If your notebook is freely accessible online, might you not be scooped by other researchers who, although they might not be able to generate a patent from your work, could publish your findings before you?

A: People do argue that. In his book ***The Telephone Gambit***, however, Seth Shulman points to an interesting historical incident that makes the case for open notebooks. By examining the lab notebook kept by Alexander Graham Bell when he was developing the telephone, Shulman shows that Bell actually stole the idea for the initial telephone from **Elisha Gray**. And he managed to do that by examining a provisional patent application (at that time called **a caveat**) that Gray had filed with the U.S. Patent and Trademark Office.

Bell's notebook wasn't publicly available until 1990, so at the time, no one would have known what he had done. But with ONS, you share things in very fine detail on an experiment-by-experiment basis. The transparency that it provides makes it much easier to see exactly who has contributed what.

Q: Other skeptics caution that if researchers put their notebooks online, they will not be able to get papers published in scholarly journals. Is that a valid concern?

A: It's true that if you write papers that you plan to submit for peer-reviewed publication on a public wiki, those papers are by definition preprints, and so copyright issues can arise. For instance, it would mean that you couldn't publish in an **ACS** journal since ACS doesn't allow preprints.

However, you don't have to do it that way: You could choose to write your papers in a closed manner rather than on a wiki and yet still use an open notebook. We haven't actually tried to submit to an ACS journal in this way, but I think there is a good chance they would accept it because the actual text that we would send to them would not have been published or displayed anywhere, so there would be no copyright issue. However, that remains to be tested.

On the other hand, you could simply choose to publish in journals that do not prohibit preprints, which we do. More specifically, we try to publish in open access (**OA**) journals as much as possible. Doing that fits better with our philosophy of openness.

Q: Another point often made is that promotion and tenure (P&T) committees don't view web-based work as assessible research. As a result, some argue that scientists who practice ONS are putting their careers at risk. Do you agree?

A: It depends on how you look at it. If you think about it, researchers use the telephone a great deal. But when they go up for tenure, they don''t say how many hours they spent on the telephone because the telephone is simply a tool to achieve something else.

The way I look at this is that it is not a question of how much time you spend online, but what you achieve by doing so. For instance, if it allows you to find a collaborator with whom you are able to publish several papers, then it is worth whatever time you spend, be it on the telephone or on the web.

So when people make that claim they are framing the issue in the wrong way. Personally, I always list all the things we have done that have not been peer-reviewed. Tenure committees can then make what they will of it.

Q: So long as they continue to publish papers in peer-reviewed journals, researchers have nothing to fear from practicing ONS?

A: Exactly.

Q: Do you think ONS is only relevant to certain disciplines? Those working in medicine or the social sciences, would at the very least need to make their data anonymous before making it public?

A: That's true. The thing about chemistry is that you do experiments. These are all done in the lab, and all your work is recorded in your notebook. So the concept of ONS is extremely applicable to the work we do. In fields such as medicine, that won't be the case. In fact, it is my understanding that not all scientific fields even maintain lab notebooks.

But while I accept that in areas such as medicine there may be issues that limit the use of an open lab notebook, there are many other things that researchers could be doing to be more open. Practically every discipline could be far more open than it is today.

Q: The Wikipedia entry on ONS implies that there is a connection between ONS and citizen science. You mentioned SETI@Home earlier, and I know that members of the public can contribute to a number of science projects today (e.g., FoldIt and the Open Dinosaur Project). Can you envisage ordinary citizens contributing to your work?

A: When we started ONSchallenge, we did envisage that high school students might contribute, by doing solubility measurements for commonly available compounds such as aspirin and using a solvent such as **isopropyl alcohol**, both of which can be bought in any pharmacy.

As yet no opportunity has arisen where that would make sense, although I could certainly see it happening. A teacher at a high school, for instance, might want to run a project and contribute the results to the challenge.

Actually, Brent Friesen, who teaches sophomore organic chemistry at **Dominican University**, did at one point incorporate ONSchallenge into the first week of his lab. So these things can happen.

That said, I realize that you were really asking whether someone who is not well versed in chemistry could contribute to what we are doing. And the answer is that so far as the malaria project is concerned, it would not be possible. However, under certain circumstances, I could see it working for the solubility project.

Durability

Q: Since digital information is notoriously fragile, how you can be sure that your notebook and the data associated with it will persist over time, particularly since it is being hosted by third-party providers such as Google?

A: One nice thing about using the tools we do is that it is easy to archive the data. And Andy Langhas has written some code that allows us to pretty much archive an entire lab notebook quite easily, including all the associated data. This is then automatically stored on Excel spreadsheets that retain all the calculations and the calling of web services that we put into the notebook.

This means we can take a regular snapshot of the notebook and put it in our library repository. So if, for whatever reason, Google were to change its terms and conditions, we would still have all the data archived elsewhere. In addition, every couple of months, we spit out the entire archive and convert it into **book format**.

Q: You mentioned the ONS Solubility Challenge book and a Reaction Attempts book. Do you view these books primarily as preservation tools then?

A: There are a number of things going on. First, I am a great believer in redundancy, and you never know when you are going to be happy that you have another way of getting hold of your information. Additionally, a book is a very tangible thing and also has an ISBN number, so it can be cited in a different way.

A physical copy has a number of other advantages too. For instance, when I talk about the ONSchallenge project, I can hold up the book and show the past winners. And I can show the measurements that were made. We also make the book available on **Lulu.com**, where it can be bought for the cost of printing.

The books are also handy to have in the lab, as often they are more convenient to use than the computer, depending on what you are looking for. True, you can't do sophisticated searches on a print book, but if you do need to, you just go to the computer.

Finally, downloading the archive as a book allows us to offload the content to **Nature Precedings** too. Nature Precedings pretty much only accepts PDFs, so we can't just upload our data directly from the archive.

Q: You view Nature Precedings as an archival service too?

A: Correct. Although it's more than that as people generally prefer to cite Nature Precedings over many other sources. By putting it in Nature Precedings, we also get a **DOI**.

Publishers and Librarians

Q: You said earlier that it is important to carry on publishing in peer-reviewed journals because that is how researchers are assessed for tenure. But will this change? Scholarly publishers are under considerable threat from OA, and a lot of effort is currently going into developing new metrics to replace the controversial journal impact facto r , many of which efforts are focused on article-level measurement. As OA, Open Data, and Open Science at large continue to develop, what implications do you see for scholarly publishers?

A: Do you mean in terms of business models?

Q: Among other things, yes. For instance, there is a view that the only role left to publishers in the future will be that of managing peer-review. That implies a much reduced role, and so their revenues would surely fall dramatically to the point where there may no longer be a viable business for commercial publishers?

A: Actually, so far as ONS is concerned I can see some complementarity between what we are doing and the existing system. In the last article we published, for instance, we included links to our lab notebook as references, as well as links to Nature Precedings.

At the moment, the two systems can happily co-exist: You make your point in your paper, and then you link to the best possible source, which might be another paper, but it could just as well be a lab notebook page.

Consequently, I see don't see ONS having either a negative or a positive impact on publishers, just some technical implications. As we discussed, this is all headed for the semantic web, and from that perspective open lab notebooks begin to become databases that publishers can query.

Q: Can you expand on that?

A: If you consider the RSC's **Project Prospect**, you can see that publishers are definitely trying to make their articles more machine-readable and trying to incorporate external machine-readable information into those articles too.

I don't know how (and whether) publishers can actually make money out of all this. One could imagine that Elsevier might decide to host lab notebooks itself, and then make them toll-access. One can imagine all kinds of possible scenarios. However, our strategy is to stick to free tools for as long as possible.

I can't say how publishers will react to all this. But I can see that OA raises huge issues for their business models. Once you have published a few papers in OA journals, it becomes very addictive, and you start to find it extremely difficult to bring yourself to submit to journals that charge an access fee: Toll-access makes it so much more difficult to share things; and as people realize that they will want to be more open in general.

Q: Do librarians have a role to play in ONS-enabled science?

A: Librarians definitely have a potential contribution to make. I mentioned that we regularly take a really good snapshot of our notebook, and that one of the places we archive it is in the library repository.

Q: So the library has an archival role to play here too?

A: Right. And the institutional repository is the obvious place to do that archiving. So with every edition of the books we create, we add a link to the archive hosted by our library.

And there is another valuable role libraries can play here. I don't know whether you are aware of it, but any document placed in a university's institutional repository is automatically considered scholarship by **Google Scholar**. Google Scholar is not a trivial thing. It is used by a lot of scientists specifically as a free way of accessing scientific information.

That means that the library's role is not just hosting documents but giving them validity too, not by means of peer-review but by giving them credibility, signaling to the world that they can be considered a professional resource. After all, that is what Google Scholar is assuming when it indexes documents in institutional repositories.

As I understand it, documents posted in Nature Precedings are also automatically included in Google Scholar.

Q: Are you saying that simply by putting material into an institutional repository, librarians are (whether they are conscious of it or not) tagging that material as bono fide scientific research?

A: Exactly. And so librarians have an important role to play in the ONS space: Archiving lab notebook content in highly indexed databases and giving it a stamp of authority as a result.

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